

# SYSTEM-OF-SYSTEMS

## System-of-Systems (SoS) Modeling and Analysis

### Highlights

#### Why is System-of-Systems Analysis Important?

- Systems are becoming increasingly complex and interdependent.
- The ability to assess and predict SoS effectiveness is essential for critical business decisions.
- Many challenges in government, industry and national security are cross-disciplinary and based upon collections of systems working synergistically.

#### What are the Objectives for Developing this Capability?

- To create the ability to capture key system interdependencies and measure effectiveness at the SoS level.
- To capture true SoS performance for highly interdependent systems.
- To evaluate performance metrics as a function of system functions that can be operational, degraded, or failed.

#### Characteristics of a System-of-Systems

- Component systems of a SoS have operational independence.
- Component systems are separately acquired and continue to be managed independently.
- A SoS evolves over time, with component systems capabilities added, removed, or modified as needs change and experience is gained.
- A SoS has emergent capabilities and properties that do not reside in the component systems alone.
- SoS component systems can be geographically distributed but have the ability to readily exchange information.

### System-of-Systems Overview

The science of System-of-Systems (SoS) is still in its infancy and thus concurrence on a single definition has yet to occur. However there are common themes among the diverse definitions. The first is the assumption that individual systems must have their own independent operational capability. The individual systems may be, but are not required, to be geographically dispersed. This is part of what makes a SoS complex in nature. Finally, the individual systems form into a SoS with emergent behaviors and capabilities that couldn't exist independently.

There are many examples of what academics and industry leaders refer to as a SoS. Consider a combat team during a high intensity mission. Several different systems and technologies must come together in order to defeat an enemy or achieve an objective. Another example is the air transportation industry. There are many technologies that support navigation, weather, and communications for hundreds of systems dispersed all over the globe.



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## Key Features and Benefits

### SoS Analytic Benefits

- Enables improved system design by expanding the scope of analysis beyond stove-piped, individual system approaches.
- Supports trade studies at a SoS level to allow better decision making for overall mission success.
- Provides a broader system view for decision makers of complex, dynamic SoS.

### Research Area Opportunities

- Incorporating network and communication impacts on SoS performance.
- Assessment of human performance impacts on SoS performance.
- Optimization for complex SoS.
- Enterprise operations analysis for large SoS.
- Susceptibility assessments for complex SoS.

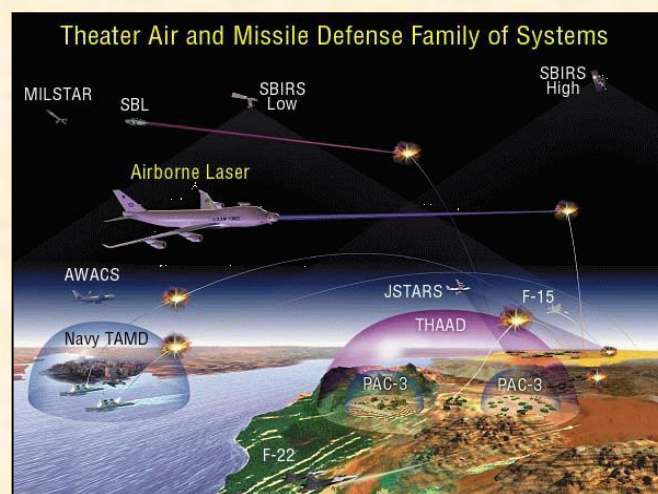
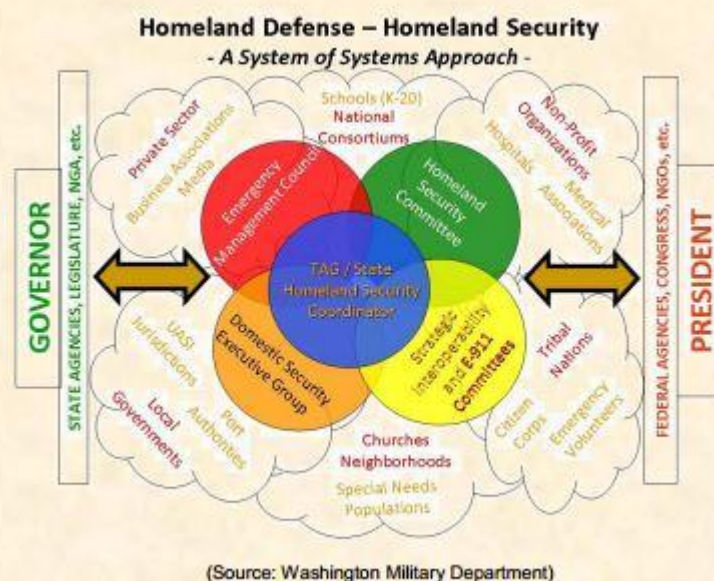
## Application Examples

### Army Ground Combat Team

- Current Army systems continue to be upgraded with new and diverse technologies. System interdependencies are increasing and enable the warfighters to perform their missions.
- Consider a platoon trying to complete an objective. The systems can communicate using line-of-site communications technology. However, even if the line-of-site communication is unavailable on the ground systems, an unmanned aerial vehicle (UAV) can provide a link for communications. Thus the combat team has additional capability beyond that of a single system.

### Missile Defense

- Systems like those involved in Missile Defense also represent a SoS. Many differing systems and technologies must interact in such a way to provide a capability that is critical to National Security.
- The capabilities of each individual technology cannot complete the overall objective. This highly interdependent system can only succeed with support from all the sum of its parts.
- Capturing the behaviors and measuring the performance of this system is essential for decision makers to understand the impacts of critical business decisions.



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